26 BRAZILIAN TEACHERS' CONCEPTIONS ABOUT CREATIONISM AND EVOLUTION

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Abstract

The identification of teachers' conceptions about evolution is important because it enables understanding, for example, how they cope with issues related to the creationism versus evolution conflict inside the classroom. This work was developed within the framework of the European project BIOHEAD-CITIZEN, which considers that scientific knowledge and teachers' attitudes and values can influence teaching practices. A questionnaire was designed for 19 countries in Europe, Africa and the Middle East. This current paper extends the BIOHEAD-CITIZEN project to a South American country, Brazil, aiming to assess the evolutionist and creationist conceptions of six groups of in-service and future teachers. The questions on evolution were worked out as dependent variables and multivariate analysis was carried out. The results agree with previous results obtained from 12 other countries, in that in-service and future biology teachers give more importance to natural selection and the evolutionary process than other groups of teachers. Compared with those countries, however, the total Brazilian sample shows a higher percentage of creationist conceptions, particularly for Brazilian biology teachers and future teachers. As discussed herein, this may not be an obstacle to teaching evolution as these teachers accept both creationism and evolutionism concomitantly.

Keywords: teaching biology; biological evolution; creationism, Brazilian teachers

1. Introduction

The assessment of teachers' conceptions about evolution is important in understanding how they cope with issues related to the creationism versus evolution conflict in the classroom. Meadows, Doster and Jackson (2000) claimed that these issues can disturb American biology teachers who think it crucial that students learn biology evolution without questioning their personal and community values or world vision, which might be in opposition to evolutionary theory. Similarly, teachers need to cope with their own unease triggered by conflicts between evolution and their religious beliefs or personal values.

This study was developed within the framework of the European project BIOHEAD-CITIZEN (Biology, Health and Environmental Education for Better Citizenship) (Carvalho, 2004; Carvalho & Clément, 2007), aimed at improving our understanding of how different aspects of citizenship are, or may be promoted through biology, health and environmental education. This project takes into account not only that scientific knowledge on these topics

is rapidly developing but also that teachers' attitudes and values can influence school practices. A questionnaire was designed, translated and validated for use in 19 countries with geographical, historical, cultural, social, religious and political contrasts in Europe, Africa and the Middle East. Some of the results on teachers' evolutionist and creationist conceptions can be found in Clément and Quessada (2008, 2009), Lopes (2008), Quessada and Clément (2010), and Quessada, Munoz and Clément (2007).

This current paper extends the BIOHEAD-CITIZEN project to a South American country, Brazil, to assess the conceptions of six groups of teachers (in-service primary school teachers, biology teachers and Portuguese language teachers, and corresponding future teachers) from São Paulo State about the topic of evolution, in particular about their evolutionist and creationist conceptions. The research questions can be formulated as follows: Do the different groups of Brazilian teachers have different conceptions about evolutionism and creationism? Are there differences between the conceptions of Brazilian teachers and those of the BIOHEAD-CITIZEN project?

1.1 The context of this work

Having been developed under the project BIOHEAD-CITIZEN, this study is based mainly on the teaching of science, but also covers the area of social psychology in the context of social representations (Moscovici, 1984). In the field of didactics of science, the term "conception" is better accepted (Astolfi, Darot, Ginsburger-Vogel, & Toussaint, 1997) than the term "representations" (Clément, 1994). Duit (2007) has produced an updated list of scientific papers developed upon the conceptions of teachers and students.

The project BIOHEAD-CITIZEN assumes that the views of different players in the educational system emerge from the interaction of scientific knowledge (**K**), systems of values (**V**) and social practices (**P**) (Clément, 2006). Although the concepts can be examined under other conceptual frameworks, the KVP model (Figure 1) has been very useful in the analysis of important characteristics of taught knowledge, enabling an understanding of the worth of a scientific presentation as related to science and values or social practices, within an epistemological scope. Knowledge (K) refers to information from the scientific community. The values (V) in this model are considered in the large sense of the term, including opinions, beliefs and ideologies. For example, sexism, racism or xenophobia are all considered, as well as the search for truth by means of science and "scientific ideologies", as defined by the epistemologist Canguilhem (1977) to characterize trends in the biological sciences, such as reductionism, anatomization or absolute genetic determinism. Social practices (P) range from teaching practices inside the classroom to the current social conception which features not only the students' future career, but also influences citizens-to-be.

The aim of the research project BIOHEAD-CITIZEN is to explore multiculturalism related to the teaching of controversial and important topics such as health education, sex education, environmental education, and evolution (especially the sensitive issue of human origin), epigenesis associated with the socio-cultural determinism of human behaviour, and reductionism in the teaching of human genetics (Carvalho & Clément, 2007).

A priori we might assume that knowledge is universal, having as its reference the same publications, and thus all curricula and textbook contents should be the same in all countries. Similarly, all teachers' conceptions should be the same, regardless of the subject they are addressing. The development of BIOHEAD-CITIZEN shows that this idea is not correct,

especially for these "live issues" that are often the topic of social and scientific debates (Albe & Simonneaux, 2002).

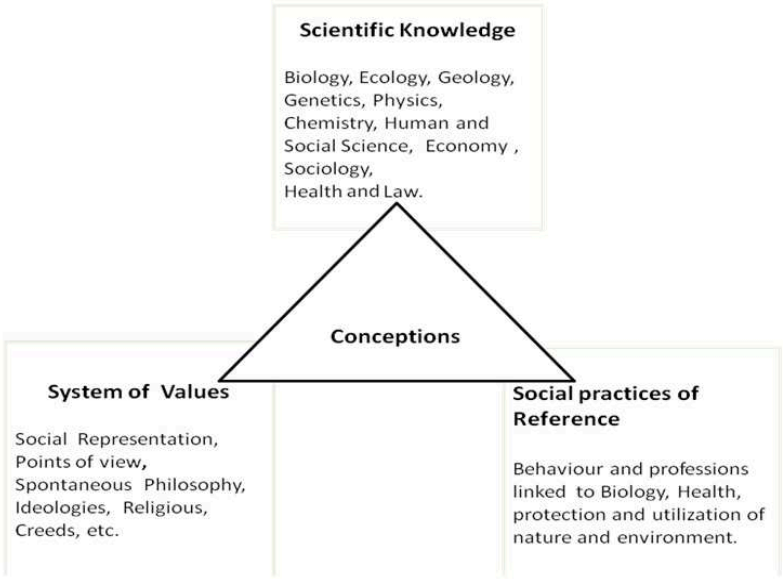

Figure 1
The KVP model. Conceptions in light of scientific knowledge, system of values and social practices of reference (Clément, 2006)

2. Evolutionism and creationism

The history of the Earth and humanity can be explained in light of creationism or evolution. The first is based on the concept that a Creator (God) gave rise to the world with all living beings, as it is today. Based on what is written in the Bible, the Anglican Archbishop James Usher (1581-1656) proposed that the world would have been created on 23 October 4004 BC at noon, i.e. around 6000 years ago (Gould,1996). The idea that all species have remained unchanged since their establishment is termed fixism.

In contrast, the theory of evolution assumes that all forms of life have undergone many changes throughout the Earth's history, including the presumed extinctions which have occurred throughout. The theory is based on evidence obtained through fossil records, analysis of anatomy and embryology, comparative biochemistry and geological and cosmological molecular studies (Mayr, 2009).

From the use of radiometric dating methods, for example, it is estimated that the Earth originated nearly 4.5 billion years ago and that life emerged on the planet approximately 3.5 billion years ago (Orgel, 1998). Contrary to creationist theory, which places the individual on a different level from other living beings, the theory of evolution, based on the proposal of the English naturalist Charles Robert Darwin (1809-1882), proposes that all living organisms descend from a common ancestor. Based on fossil evidence and molecular studies "it is likely that the lineage of the human species arose between five and eight million years ago" (Mayr, 2009, p. 28).

Given the different views on the origin of Earth and humanity, radical creationists and evolutionists have diametrically opposing views. The anti-evolutionists, i.e. the radical supporters of creationism, refuse to accept the theory of evolution. They claim that this is just a "non-proven theory" and that there is no consensus among scientists themselves about various aspects related to it. They quote as an example the age of the universe and the Earth, as well as issues which have not yet been clarified in the evolution of species. In this regard,

the geneticist Theodosius Dobzhansky, in his 1973 article entitled "Nothing in Biology makes sense except in the light of evolution", argued that there are many divergences among scientists, but those are issues that contribute to the development of science and added: "Seen in the light of evolution, biology is, perhaps, intellectually the most satisfying and inspiring science. Without that light it becomes a pile of sundry facts, some of them interesting or curious but making no meaningful picture as a whole" (p. 129).

The clash between creationists and evolutionists becomes more evident in discussions about the teaching of evolutionary theory in biology classes. A striking example is the debate that is occurring most vigorously in the United States, where society demands that the theory of evolution be taught on equal footing with that of creationism. Meadows et al. (2000, p. 102) commented on the fact that these issues put biology teachers in an uncomfortable position: "Biology teachers face the demanding challenge of crafting a learning environment that mediates colliding agendas. They want students to deepen their understanding of biological evolution in order to become scientifically literate citizens. At the same time, they also want to support, rather than undermine, the values of students, parents and communities whose worldviews can oppose the teaching of evolution. On a private and often unspoken level, many biology teachers themselves must face their own unresolved conflicts between biological evolution and their personal worldviews."

In this regard, it is pertinent to ask: What are Brazilian teachers' conceptions about the origin of life and humankind? Are they either creationist or evolutionist? Or can they believe in both ideas concomitantly? Considering that the views of different players (in this case teachers and future teachers) emerge from the interaction of scientific knowledge (K), systems of values (V) and social practices (P) (Clément, 2006), we discuss the results of our study within the framework of the KVP model.

3. Materials and methods

The entire BIOHEAD-CITIZEN questionnaire, containing 144 questions, was distributed, from September until December 2008, to six groups of São Paulo countryside teachers and university students (future teachers): 50 in-service primary school teachers (In-P), 50 in-service biology teachers (In-B), 50 in-service Portuguese language teachers (In-L), 50 future primary school teachers (Pre-P), 50 future biology teachers (Pre-B), 50 future Portuguese language teachers (Pre-L). It should be emphasized that this is a convenience sample and therefore cannot be generalized to the total population of in-service and future teachers in Brazil.

Following the guidelines of the BIOHEAD-CITIZEN project, the future teachers filled in the questionnaire at the university where they were studying, while the in-service teachers filled it in at the schools in which they were teaching. They filled in the questionnaires anonymously in the presence of the researcher, as explained in detail elsewhere (Munoz, Bogner, Clément, & Carvalho, 2009).

The fifteen "Evolution" questions used in this work are shown in the Appendix, and the answers were assessed by multivariate analysis. This method has become a standard in investigating complex data featuring the behaviour of many individuals, dependent on many variables (Lebart, Morineau, & Warwick, 1995). To analyse the answers, we used principal component analysis (PCA, Lebart, Morineau, & Warwick, 1995). We further performed a between-group analysis (Dolédec & Chessel, 1987) to complement the initial PCA (which differentiated all of the individuals) to show the differences among groups' conceptions

(groups of teachers, level of training, religions, and faith). We used the Monte Carlo test to analyse the levels of significance of differences between groups. The statistical analysis was performed using the software package SPSS statistics for Windows, version 17.

4. Data analysis and discussion

4.1 PCA of all "Evolution" variables

The PCA summarizes a large number of questions, to identify a limited set of important conceptual guidelines, characterized by a coherent set of answers to certain questions. The most remarkable eingenvalues featured principal component 1 (first bar in Figure 2), represented by the horizontal axis (C1) in Figure 3. The second component, corresponding to the vertical axis (C2) in Figure 3, was somewhat weaker (Figure 2), such that the first component expressed the highest variance among respondents (27%).

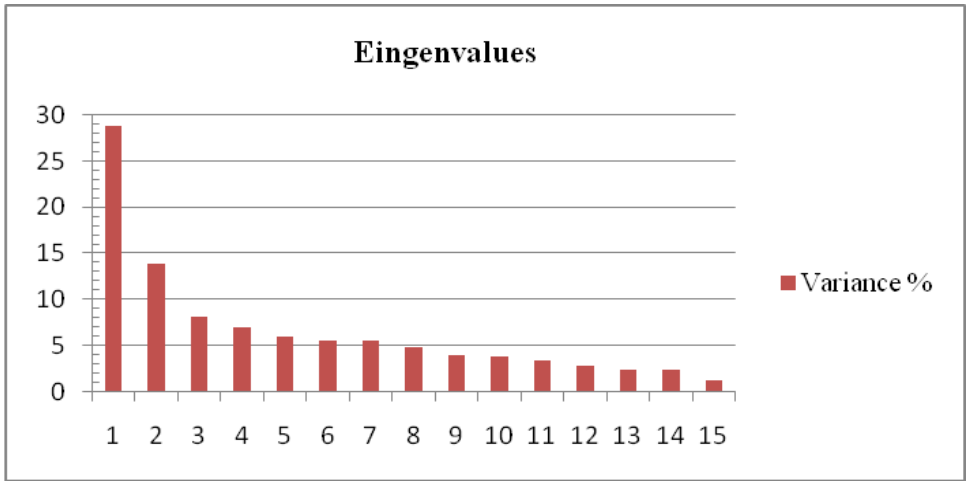

Figure 2
Histogram of eingenvalues, featuring the proportion of variance reflected by each component of the PCA
The first two bars are the most important ones and represent the axes on the graph shown in Figure 3

The "Evolution" questions, or variables, that structured principal components 1 and 2 are presented in Table 1 and projected in Figure 3.

The variables structuring axis 1 (horizontal) oppose the creationist (Figure 3, left) and evolutionist (Figure 3, right) views. These are conceptions associated to beliefs and values (V). The variables that define axis 2 (vertical) are related to familiarity with biological sciences (the role of Intelligent Design (B44), Viruses (B47) and the Surrounding Environment (B45) on evolutionary processes). These are conceptions associated to scientific knowledge (K) about evolution.

Table 1
Questions that contributed most to principal component 1, their formulations in the questionnaire and their coordinates on axes C1 and C2

	Variable/Question	C1	C2
B43	Indicate your evaluation of the importance of the following factors in species evolution (great importance; some importance; little importance; no importance at all).	0.755	0.177
B28	Which of the following four statements do you agree with most? ∗ It is certain that the origin of the humankind results from evolutionary processes. ∗ Human origin can be explained by evolutionary processes without considering the hypothesis that God created humankind. ∗ Human origin can be explained by evolutionary processes that are governed by God. ∗ It is certain that God created humankind.	0.755	0.342
A64	Which of the following four statements do you agree with the most? ∗ It is certain that the origin of life resulted from natural phenomena. ∗ The origin of life may be explained by natural phenomena without considering the hypothesis that God created life. ∗ The origin of life may be explained by natural phenomena that are governed by God. ∗ It is certain that God created life.	0.746	0.405
B48	Indicate your evaluation of the importance of the following factors in species evolution: Importance of God in species evolution (great importance; some importance; little importance; no importance at all)	0.613	0.489
B45	Indicate your evaluation of the importance of the following factors in species evolution: Importance of surrounding environment in species evolution (great importance; some importance; little importance; no importance at all)	0.601	0.515
B46	Indicate your evaluation of the importance of the following factors in species evolution: Importance of transposons (jumping genes) in species evolution (great importance; some importance; little importance; no importance at all)	0.598	0.495

Table 2
Questions that contributed most to principal component 2, their formulations in the questionnaire and their coordinates on axes C1 and C2

	Variable/Question	C1	C2
	Indicate your evaluation of the importance of the following factors in species evolution (great importance; some importance; little importance; no importance at all):		
B44	A program inside the organism (intelligent design)	0.360	0.653
B47	Viruses	0.370	0.571
B45	Surrounding environment	0.601	0.515
B46	Transposons (jumping genes)	0.598	0.495
B48	God	-0.613	0.489

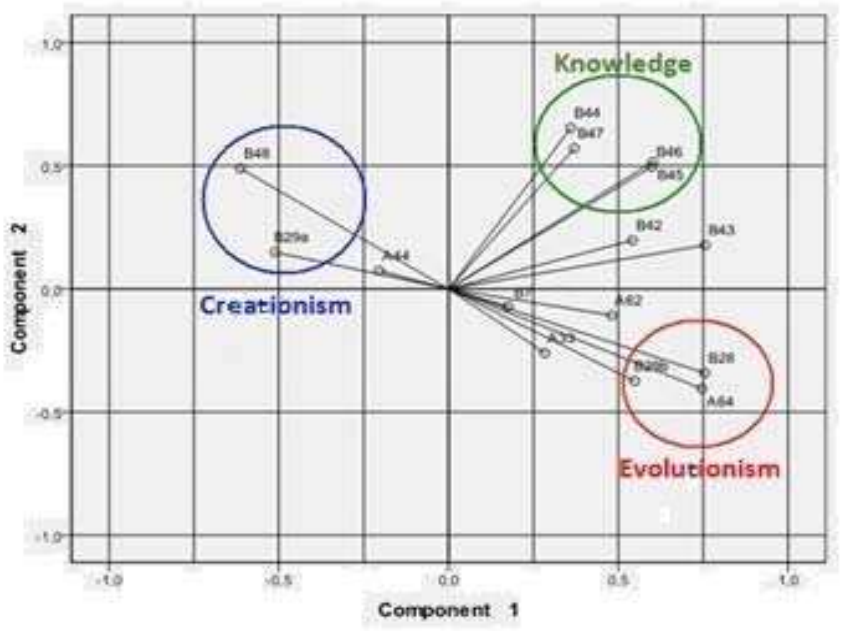

Figure 3

Graphical representation of the PCA analysis on "Evolution" questions, allowing analysis of the significance of the space defined by principal components 1 and 2 which are, respectively, the horizontal and vertical axes. Each question represents a vector; the length of its projection on each of the two axes indicates its contribution to the definition of that axis.

The circles that group the more structural issues of the axes were added manually to the graph.

Questions B45, B46 and B48 (Importance of the Surrounding Environment, Transposons and God in the evolution of species) are involved in both axes, indicating an interaction (KV) between "Values" (axis 1) and "Scientific Knowledge" (axis 2). Questions B45 and B46 come close to overlapping, and both point to the top right of the graph, indicating that the evolutionary conceptions (far right) are more correlated with the importance given to Surrounding Environment and Transposons (and therefore more positive about axis 2) and vice versa. In contrast, the B48 variable points to the left, indicating that creationists emphasize the importance of God in the evolutionary process.

The importance of natural selection, indicated by vector B43 in the top right quadrant of Figure 3, is highly weighted on axis 1 but less weighted on axis 2. This shows that natural selection is of the upmost importance for evolutionists and that creationists do not see it as relevant, perhaps rejecting it as being associated to more materialistic philosophies, such as capitalism or racism. In addition, its low weighting on axis 2 might be related to those people (creationists or evolutionists) who interpret natural selection as a scientific theory rather than an ideology, in a manner not conflicting with their moral values.

Results of the cross-tabulation between B29a and B29b (Table 3) show that out of the total sample (N=282), 6% (18) do not accept the theories of evolution or creationism, while 46% (N=132) cope well with both conceptions, suggesting that these views are not relevant to their system of values. About 20% (N=57) of the respondents accept the theory of evolution, but refuse the theory of creationism. Finally, 27% (N=75) accept creationism, but do not accept evolutionism, showing that creationism is stronger in this sample.

Table 3
Cross-tabulation between questions B29a and B29b

		Question B29b		Total
		Yes	No	
Question B29a	Yes	18	75	93
	No	57	132	189
	Total	75	207	282

4.2 Analyses between classes (groups of teachers)

Figure 4 shows the distribution of teacher and future teacher groups as a function of the two principal components (C1 and C2). In-B and Pre-B teachers are clearly separated from both In-L and In-P teachers. Between them lie the Pre-P and Pre-L groups. These results indicate that biology education may be an important factor in developing scientific knowledge about evolution.

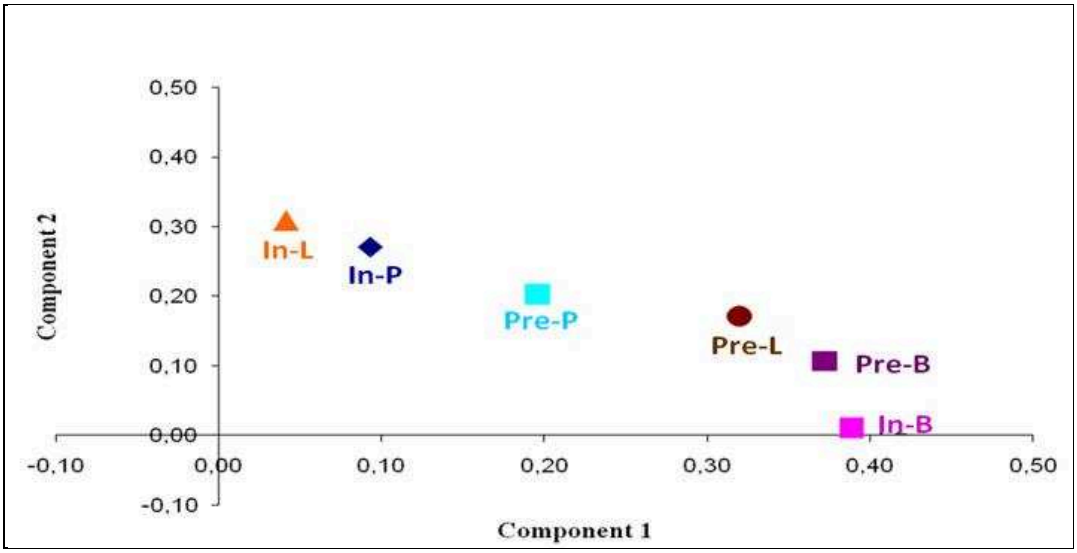

Figure 4
Distribution of teachers' and future teachers' groups as a function of the two principal components (C1 and C2)

When looking at the answers of the different groups of teachers and future teachers it becomes clear that most In-P, Pre-P, In-L and Pre-L teachers have creationist conceptions. In contrast, less than half of the In-B and Pre-B teachers have creationist conceptions (Figure 5A, B and E). In agreement with our results, a recent survey in Brazil (Schwartsman,2010) published in April 2010 in the newspaper *Folha de São Paulo,* revealed that "the majority of Brazilians (59%) matches the acceptance of Darwinian process with faith in the conduct and supervision of God, located in a plane superior to nature."

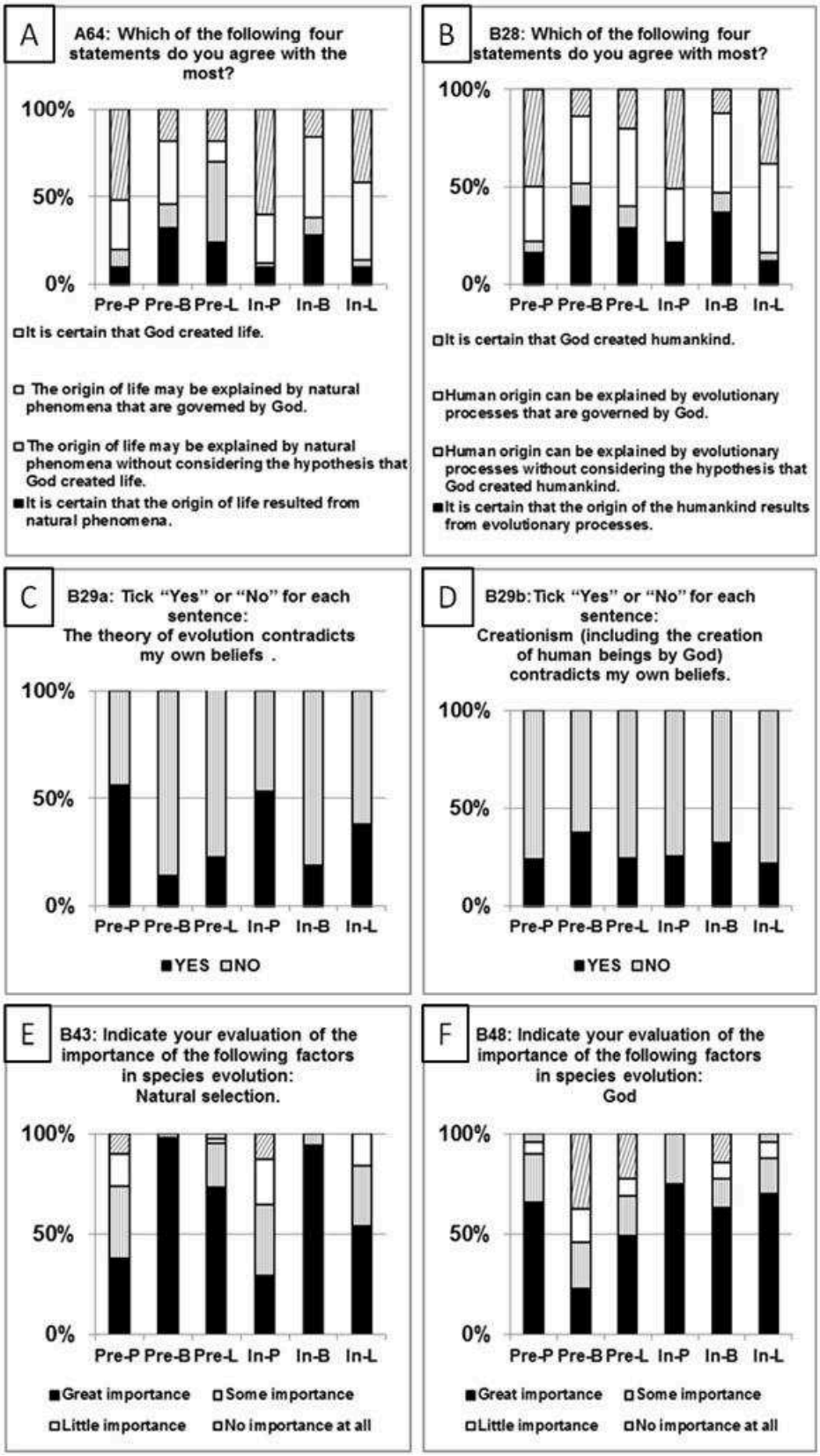

Figure 5
Answers of groups of teachers and future teachers to questions
A64, B28, B29a, B29b, B43 and B48 (A-F, respectively)

Most teachers and future teachers of all groups answered that the theory of evolution (Figure 5C) does not contradict their own beliefs; similarly, creationism does not contradict their beliefs either (Figure 5D).

Almost all In-B and Pre-B teachers (over 90%) placed great importance on the process of natural selection with respect to the evolution of species, while only 30 to 40% of In-P and Pre-P teachers, respectively, placed great importance on this process (Figure 5E). The In-L and Pre-L teachers were between these groups, ranging from 50% to 70%, respectively.

These results are in agreement with previous results from 12 other countries (Quessada et al., 2007), in that the biology teachers and future biology teachers gave more importance to natural selection and the evolutionary process. However, the total Brazilian sample showed a higher percentage of creationist conceptions.

5. Final remarks and conclusions

With the KVP model in mind (Clément, 2006), our results show a strong influence of religious values (V) on conceptions about the origin of life and humankind, and they show that this influence is less strong for biology teachers and future teachers than for the other groups, indicating that Knowledge (K) is an important factor in acceptance of the theory of evolution and rejection of God's influence on the creation of life. The variable "social practices" (P) was not focused on in this study. Although in general our results are in agreement with previous studies carried out within the BIOHEAD-CITIZEN project (Quesada & Clément, 2010; Quessada et al., 2007), the Brazilian in-service and future biology teachers still showed a stronger effect of religion relative to the other countries studied.

All of the Brazilian respondents forming the groups of in-service teachers and future teachers understand the importance of natural selection for evolution. On the other hand, almost half of them do not invalidate the hypothesis of a Creator who rules that process. This reinforces the studies by Quessada and Clément (2010) claiming that evolutionism and creationism are not necessarily conflicting views. Furthermore, in this sense, we also agree with Gould (1999) who argues that religion and science are "non-overlapping magisteria", having separate domains of teaching authority.

Why do the respondents accept both creationist and evolutionist ideas, with no apparent conflict between them? Does this constitute an obstacle for evolution teaching?

One possible answer to the first question can be taken from the model of changes in conceptual profile (Mortimer, 1995), which explains that people do not need to abandon or replace their previous/alternative conceptions to understand a scientific concept, i.e. it is possible for two or more meanings of the same word or concept to coexist in a single person, to be evoked in the suitable context. In this sense, it is plausible that the in-service and future biology teachers in this study understand the ideas of evolution without dismissing their own world views. As stated by El-Hani and Bizzo (2002, p.19): "…the teaching of science should, above all, show students how a set of problems is solved by the scientific perspective, broadening the spectrum of possibilities available to them. Now, the question of whether or not students believe in the scientific conceptions, rather than only understand them, can be properly understood as a problem of an intimate nature of the student being examined by him in the context of his worldview, in the light of ideas that have strength and power."

We understand that the teacher's acceptance or refusal of evolutionist ideas is a personal matter, as it is for students. Inside the classroom however, the teacher's role is to arouse

students' motivation to understand the scientific concepts and to explain that within their own individual contexts, scientific conceptions and alternatives have their validity and range (El-Hani & Bizzo, 2002). This obviously does not mean that values and creeds should be taught on an equal footing with science in the classroom. However, teachers should promote the explication and discussion of values and creeds so that the students acquire a critical attitude about life and, in this way, they can corroborate toward better citizenship.

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Appendix

"Evolution" questions:

A33. The emergence of the human species (*Homo sapiens*) was just as improbable as the emergence of any other species.

I agree I don't agree

A44. The emergence of the human species (*Homo sapiens*) was the aim of the evolution of living species.

I agree I don't agree

A62. In the list below, tick the THREE expressions that you think are the most strongly associated with the origins of humankind.

☐ Adam and Eve ☐ Australopithecus ☐ Creation ☐God ☐ Natural Selection

A64. Which of the following four statements do you agree with the most? (tick only ONE answer)

☐ It is certain that the origin of life resulted from natural phenomena.

☐ The origin of life may be explained by natural phenomena without considering the hypothesis that God created life.

☐ The origin of life may be explained by natural phenomena that are governed by God.

☐ It is certain that God created life.

B7.	The chimpanzee should be included in the genus *Homo*, notably because 98.5% of its DNA is identical to that of *Homo sapiens*.	I agree	I don't agree

B28. Which of the following four statements do you agree with most? (select ONLY one sentence)

☐ It is certain that the origin of humankind results from evolutionary processes.

☐ Human origin can be explained by evolutionary processes without considering the hypothesis that God created humankind.

☐ Human origin can be explained by evolutionary processes that are governed by God.

☐ It is certain that God created humankind.

B29. Tick "Yes" or "No" for each sentence:

B29a - The theory of evolution contradicts my own beliefs.

☐ Yes ☐ No

B29b - Creationism (including the creation of human beings by God) contradicts my own beliefs.

☐Yes ☐ No

Indicate your evaluation of the importance of the following factors in species evolution. (tick only ONE box for each line)

		Great importance	**Some importance**	**Little importance**	**No importance at all**
B42	Chance				
B43	Natural selection				
B44	A program inside the organism (intelligent design)				
B45	Surrounding environment				
B46	Transposons (jumping genes)				
B47	Viruses				
B48	God				

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Authenticity in Biology Education

Benefits and Challenges

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